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ABSTRACT

This paper describes briefly the secondary education milieu from which has come students in engineering technology education programs. The paper is based entirely on the published reports of other writers and is intended only to provide an overview of the research which has been done on the American high school, on American high school students, on the process of vocational choice, on career preparation routes from high school through college, and on some characteristics of scientific-technical workers. Finally, some possible implications for engineering technology education are presented. (Author)

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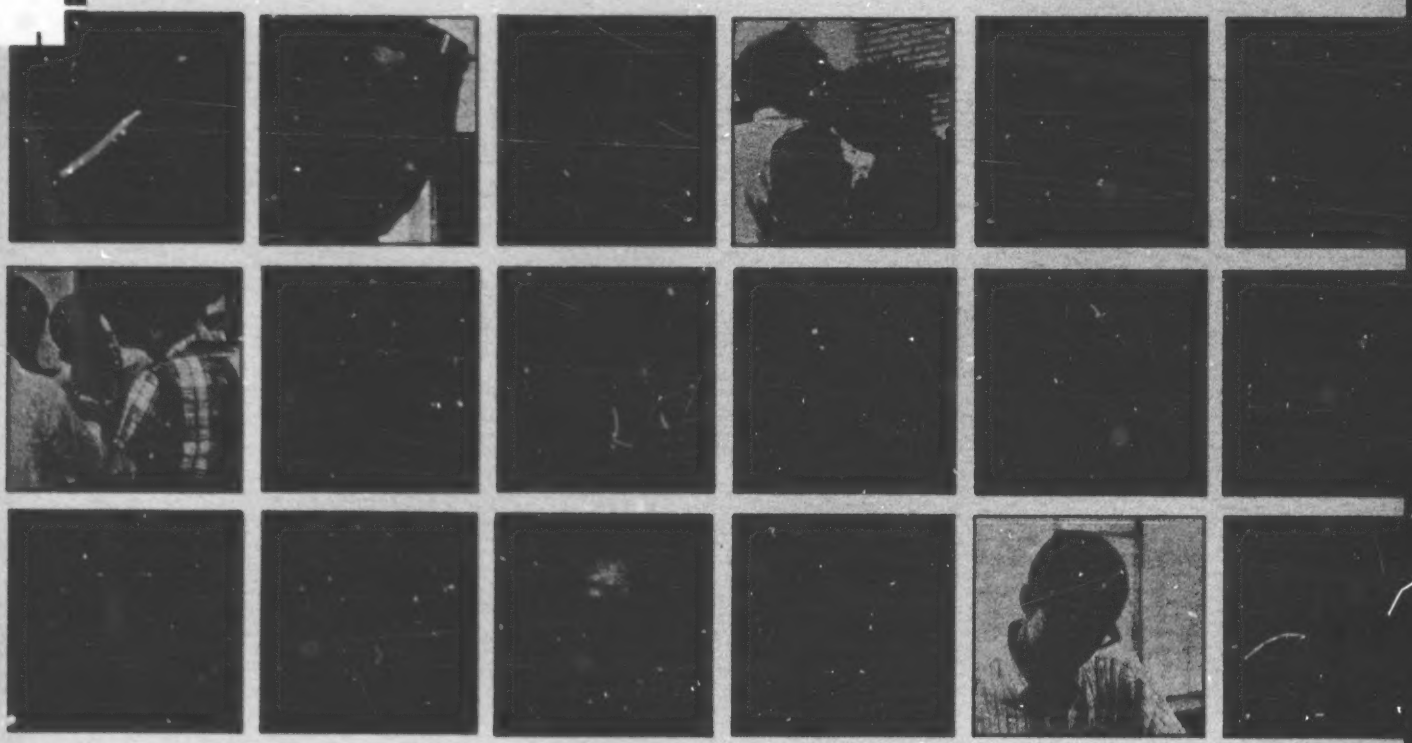

THE TECHNICIAN'S PEER GROUPS:
A Review of Some Research on High School Students

American Society for Engineering Education
1970

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THE TECHNICIAN'S PEER GROUPS: A REVIEW OF SOME RESEARCH ON HIGH SCHOOL STUDENTS

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ETE Study Report No. 5
March, 1970

THE TECHNICIAN'S PEER GROUPS: A REVIEW OF SOME RESEARCH ON HIGH SCHOOL STUDENTS

Introduction

This paper describes briefly the secondary education milieu from which has come students in engineering technology education programs. The paper is based entirely on the published reports of other writers and is intended only to provide an overview of the research which has been done on the American high school, on American high school students, on the process of vocational choice, on career preparation routes from high school through college; and on some characteristics of scientific-technical workers. Finally, some possible implications for engineering technology education are presented.

The major sources for this paper have been the reports of *Project TALENT*, a Cooperative Research Project by the American Institutes of Research and the School of Education, University of Pittsburgh, under contract with the U.S. Office of Education. *Project TALENT* is a longetudinal study of nearly half a million students who were enrolled in American high schools (ninth through twelfth grades) in 1960; the study design includes follow-up activities after 1, 5, 10 and 20 years. While data collection will not be complete until 1983, a wealth of information, collected during the period 1960-68, is already resident in *Project TALENT* files.

The paper has been prepared for the information of the members of the Advisory Committee for a national study of engineering technology education being conducted by the American Society for Engineering Education and supported by the National Science Foundation.

American High Schools

Overview

In the United States there are more than 23,000 senior high schools, of which approximately 19,000 are public institutions. The majority (94%) of the public high schools classify themselves as "general comprehensive" institutions; of the remainder, some are "vocational" high schools and others purport to offer only "academic" curricula. At least 14 million pupils--93% of the 14-17 year age cohort--are enrolled in the secondary school system, most in senior high schools or junior-senior combinations.

The "Typical" High School

On a national basis, the "typical" high school is quite small: Almost 80% of American senior high schools have fewer than 100 pupils in the 12th grade; about 70% are rural or located in "small" towns. The typical high school is likely to be part of a K-12 or 7-12 school. It spends about $625 per pupil. Its teachers have an average of 10.5 years experience and earn an average annual salary of $7,560. It has slightly more men than women in teaching positions. Classes average 23-25 pupils in a building which is about 24 years old. There is a 3-out-of-4 chance than a guidance program is available. Its principal is a middle aged man with over 20 years educational experience and a graduate degree. This "typical" school sends about 35% of its senior boys on to college, but about 10% of its 10th grade boys drop out before graduation.

A Classification System

American high schools vary greatly in enrollment, class size, expenditures, faculty experience and qualifications, kinds of pupils enrolled, curriculum offered, and many other parameters; probably no two are alike. Yet, in spite of this diversity, it is possible by the use of multiple regression statistical techniques to classify the total institutional population into a relatively small number of distinguishable groups. Each group in the resulting taxonomy has appreciable internal homogeneity and, at the same time, differs significantly and meaningfully from all other groups in terms of educational outcomes.

The major discriminants which place a school into a group are related to location. Location by geographic region, location in a rural, a small town, a small city or a large city environment, and location in regions of low-cost or high-cost housing are the variables which best serve to group and classify high schools, with one exception. Vocational high schools--regardless of the other factors--constitute a homogeneous group and are separately classified. The taxonomy which results is given in Table 1.

Case Studies of High Schools

In the following paragraphs are given brief descriptions of one representative each of certain of the taxonomy groups listed in Table 1. Each school described is an example of all those in its group, and serves as a case study for the group. These case studies are merely exemplary rather than exhaustive; it was not deemed necessary to treat all seventeen groups in the taxonomy.

TABLE 1.--Taxonomy of American High Schools

Type	Description
1	All vocational high schools
2	Big city schools, low cost housing low income
3	Big city schools, moderate and high cost housing
4	Medium city schools, low cost housing, low income
5	Medium city schools, moderate and high cost housing
6	Northeast, urban, low cost houring, low income
7	Northeast, urban, moderate and high cost housing
8	Northeast, small town
9	Northeast, rural
10	Southeast, urban, low cost housing low income
11	Southeast, urban, moderate and high cost housing
12	Southeast, small town
13	Southeast, rural
14	West, urban, low cost housing, low income
15	West, urban, moderate and high cost housing
16	West, small town
17	West, rural

NOTES: Big City - more than 1.5 million population;
Medium City - 250,000 to 1.5 million population;
Urban - 5,000 to 250,000 population;
Small Town - less than 5,000 population

A Vocational High School (Group 1)--Grades 9 through 12; state accredited; math and science classes average about 34 students, others 28; 345 seniors; homework assigned averages one hour per day; staffed with fully certified teachers, many with advanced degrees; low teacher turn-over rate; very high per-pupil cost; very low achievement level (as measured by *Project TALENT* tests), the lowest in its district; limited offerings in science and math, with no physics taught.

A Big City School in a High Quality Housing Area (Group 3)--Total enrollment over 6,000, with nearly 1,800 seniors; accredited by both region and state; about 34 students in all classes; homework assigned averages 3 hours per day; most faculty have advanced degrees and all are fully certified; 75% of students are in the college preparatory curriculum and a large percentage do go to college; high achievement level; extensive offerings (including "accelerated" courses) in math, science, foreign languages, and classical studies.

A Western Rural High School (Group 17)--A K-12 school, with 30 in high school, 7 seniors; accredited by state; class size is 13 in science, 16 in other subjects; assigned homework averages an hour and a half per day; nine or more "study periods" per week; school has newspaper, annual, orchestra; 500 volumes in library; building is 42 years old; serves an area of "moderate" priced homes; four high school teachers, all certified, all men, all teaching multiple disciplines, mainly outside the area of preparation; 55% of the boys and 35% of the girls go to college; complete science and math curriculum (including "college algebra", but not calculus); no foreign language; very high achievement level by students, especially in areas of abstract reasoning.

A Southeastern Rural High School (Group 13)--A K-12 school, with 78 high school pupils, 12 seniors; accredited by state; average class size is 22; 1.5 hours of homework is assigned daily; library includes 1,000 books; building is 17 years old, but newly renovated; school serves low cost rural homes; no minority groups are represented; starting salaries for teachers are low; teachers average 15 years experience; science curriculum includes only remedial arithmetic, general mathematics, beginning algebra; science curriculum contains only general science and biology; no foreign languages are taught; very low achievement level and very low abstract reasoning level, with high drop out rate.

A Western "High-Quality-Housing" High School (Group 15)--Enrollment is 600 in the high school grades of a 1-12 grade school; regionally accredited; class size in science is 25, 31 in other subjects; from 2 to 3 hours of homework is assigned per day; 5 study periods per week; the facilities are 45 years old, but renovated in the past 3 years; school has student publications; orchestra, glee club, national honor society, drama group, dances, athletics; teachers earn average salaries; the school serves an urban area of moderately priced homes; science curriculum is complete, but without "accelerated" program; math curriculum includes intermediate algebra, plane and solid geometry, trigonometry, but not college algebra; Spanish and Latin are the foreign languages; student achievement is at the median or just below, but 45% of the boys and 35% of the girls go to college.

A "Medium City" School in a High Quality Housing Area (Group 5)--Enrollment is 900, with 170 seniors; regionally and state accredited; class size in science is 28 and is the same for other classes; from 1 to 2 hours of homework are assigned daily; two study periods per week; library contains 2,700 volumes; building is old, but recently renovated; a full spectrum of student activities is offered; teachers generally are certified, have master's degrees, and teach in their discipline of preparation; teachers earn moderately high salaries but

remain at the school somewhat shorter than average periods of service; the school serves a suburban area of moderately priced homes; the traditional science curriculum is augmented with advanced physics and "home science"; the math curriculum includes intermediate algebra, plane and solid geometry, and trigonometry, but excludes "college algebra"; two years each of French, Spanish and Latin are offered; the student drop-out rate is low; 65% of the boys and 35% of the girls go to college; the general level of aptitude and achievement is moderately--but not exceptionally--high.

Relationships Between School Outcomes and School Types

If a battery of measures of student achievement, aptitude, and behavior are miltiply correlated with a battery of measures of school and community characteristics, it should be possible to extract certain factors which appear to be related to "desirable" outcomes. The reader is cautioned that statistical relationships so extracted do not necessarily imply cause-and-effect relationships; however, the school and community characteristics which best serve to "predict" school outcomes are interesting and worthy of study, even though interpretation is often highly complex.

Multiple regression studies have been made using, among others, the "outcome" and "predictor" variables listed below:

Outcome Variables (Student achievement and behavior)

Reading Comprehension Test
English Test
Spelling
Capitalization
Punctuation
English Expression
Mathematics Reasoning
Mathematics (Introductory)
Mathematics (Advanced)
General Information
Physical Sciences Information
Mechanical Information
Abstract Reasoning
Creativity
Mechanical Reasoning
Absentee rate
Drop-out rate for boys
College attendance for boys
Percent going to Junior College

Predictor Variables (School and Community Characteristics)

Location of school	Study Halls
Class size	Homework Assigned
Quality of housing	Summer School Policy
Per-pupil expenditure	Number of Books in Library
Senior Class size	Guidance program
Teachers Salaries	Age of building
Graduate Degrees	Accelerated Curriculum
Accreditation	Teacher turnover rate

The results of the multiple regression studies suggest that certain outcomes are highly associated with certain combinations of school characteristics. For example, the student outcomes in terms of test scores on the achievement tests vary markedly with the location of the school. (It was, in fact, this variation which led to the development of the taxonomy presented earlier in this paper.) There are certain other variables which appear to define differences both between and among school groups.

An interesting finding of this study, although not specifically related to school characteristics, was that absenteeism is more related to student aptitude than is drop-out rate. The full range of aptitudes is represented in students who drop out of school; students with poor attendance records usually are those having test scores near the low end of the distribution.

Student achievement in English is related to enrollment in an academic curriculum (i.e., not in a Group 1 Vocational School), having well-paid teachers, having a large and adequate library, having considerable homework, and having study halls. In other subject areas, the size of the school library had no relationship to student achievement.

It is interesting that certain variables have no value in predicting any of the student outcomes. For example, characteristics such as class size, size of school, and location in the suburbs, which have long been considered critical as factors in the achievement of school excellence,

correlated negatively with student achievement, if at all. The age of the school building also had no relationship to achievement, and neither did accreditation. The major variables which did contribute were teachers' salaries, length of teachers' experience, number of library books, and per-pupil expenditure.

That so few measurable school characteristics influenced educational outcomes may have implications for education. The startling finding from *Project TALENT's* multiple regression study of school characteristics is that besides location--by geographic region, by a rural-urban dichotomy, and by a socio-economic dichotomy measurable in terms of housing costs--the only variables significantly related to student achievement seem to be ones which contribute directly to the cost of classroom instruction (teachers' salaries, library books). Even other school expenses, such as facilities costs, clerical support, and pupil transportation costs are not associated at statistically significant levels with student achievement.

Summary

American high schools differ from each other in many ways, yet have so many characteristics in common that they can be classified effectively for predicting their performance into a taxonomy of 17 archetypes, mainly dependent on school location. The educational outcomes of a given school are highly predictable if it can be determined whether the school is a vocational school, in a city, in the Northeast, Southeast, or elsewhere in the county, in an urban, small town, or a rural area, or in a high-cost or low-cost housing area; additional useful data is whether the school pays its teachers well, is staffed with experienced teachers, has a large library, and has a moderately high per-pupil expenditure.

The "typical" high school is in a small western or midwestern rural community, exists as part of a K-12 or 7-12 system, sends 35% of its boys to college, and loses 10% of its pupils to drop out.

Students in the Northeast achieve higher than national norms; students in the Southeast (especially urban, low income areas) achieve lower than the national norms. Students in cities achieve high if they come from a high socio-economic area; low, otherwise. And students in vocational schools fall well below mean achievement levels.

High School Students

Overview

The *Project TALENT* study and a number of other research efforts have sketched a generalized picture of high school students. Portions of this picture, it is believed, have relevance for the engineering technology education study; hence, a brief summary of findings is given in the following sections of this paper.

Extracurricula Activities

Extracurricula activities in the high schools reach a substantial number of boys but fewer boys than girls. The kinds of activities and the percentages of boys reporting participation in them are given in Table 2. In addition,

TABLE 2.--Participation by High School Boys in Extra-Curricular Activities

Activity	Percentage Reporting Participation
Publications (paper, magazine)	28
Subject matter clubs	37
Debate, Drama, Music	38
Hobby Clubs	38
Farm Youth Clubs	23
Church, Religious, Charitable groups	68
Informal Neighborhood Clubs	50
Political Clubs	9
Social Clubs (fraternities, etc.)	23
Military or Drill Groups	15

45% of the boys had been head of an organization, and 64% had been an officer or committeeman.

Work and Study Characteristics

Boys reported a mean of 4.6 hours per week "doing chores at home," and a mean of 5.8 hours per week "working outside the home." Less than half (40%) of high school boys graduate from the high school in which they originally enrolled; 10% in fact, change schools five or more times.

High school boys average 4.4 days absent per school year. They report studying 8.25 hours per week out of class (including scheduled study halls), 3.25 hours of which are at home.

Nearly half the boys (48%) are enrolled in the "college preparatory" curriculum; 25% are in the "general" curriculum; and 7% are in the "commercial" curriculum.

High school boys report as follows on subjects which they "never enrolled in":

Business Subjects	27%
Vocational education or shop	34%
Foreign Language	48%
Math beyond arithmetic	8%

College Aspirations

High school senior boys, when asked about their expectations for college attendance, replied as follows: 53% stated they expected to attend immediately after graduation; 73% stated they they expected to attend "eventually"; and 73% stated that they expected ultimately to graduate from college. The proportion of boys which actually attended college immediately after high school graduation was reasonably close to expectation, namely, 49%.

The expressed college choices of high school seniors are interesting. Table 3 lists some of the choices expressed, along with the percentage of boys making the choice. The percentages of actual college degrees awarded during the 1960-61 academic year is also listed in Table 3 for comparison purposes. It is readily apparent that college aspirations of high school senior boys do not match realistically the output of colleges.

TABLE 3.--College Curriculum Choices of High School Senior Boys

Curriculum	Percentage of Boys Choosing Curriculum[a]	Percentage Of Degrees Awarded[a]
Agriculture	3.7	1.9
Biological Science	2.5	5.3
Business and Commerce	14.2	20.0
Education	5.4	11.5
Engineering	2[illegible].9	15.4
English, Journalism	[illegible].7	6.0
Health Professions	6.4	1.2
Mathematics	4.0	4.2
Physical Science	6.4	6.0
Social Science	2.5	18.7

[a]Detail does not add to 100%; only a few sample items are reproduced here.

High school senior boys were also asked to identify a *career* which (1) they expected to enter, and (2) which they would "most like"; some of the results are given in Table 4. (The reader should note that *career expectation* is a different variable from *college curriculum choice*, reported previously.)

TABLE 4.--Career Expectations and Preferences of High School Senior Boys

Career	Percentages of Responses	
	Expected[a]	Most Liked[a]
Accountant	4.8	4.4
Biologist, etc.	1.4	1.6
College Professor	.6	.7
Engineer	17.7	18.2
High School Teacher	5.8	4.6
Lawyer	3.4	4.1
Physical Scientist	3.0	3.5
Business man	7.4	5.7
Physician	2.5	3.0
Craftsman	1.2	1.1
Engineering or Scientific Aids	1.0	1.0
Farmer	4.1	3.9
Skilled Worker	6.9	6.2
Structural Worker	1.5	1.5

[a]Detail does not add to 100%; a partial report only is given.

Overall, 48% of high school boys plan careers in professional or technical fields; however, National surveys of manpower utilization indicate that in the United States only 15% of the employed males in the 25-29 year age group work in such fields. The mismatch among abilities, early preparation, career goals, employment opportunities and other factors is apparently widespread with high school youth.

Follow-up Studies

High School Graduates One Year Later

The population of high school students in the *Project TALENT* Study was followed up extensively. A follow-up in 1961 revealed for boys who were high school seniors in 1960 that 2% had not graduated from high school, 36% had entered a four-year college, 9% had entered a two-year college, 6% were in an armed forces school, 3% were at a trade or apprentice school,

2% at a technical institute and 2% at a business school; altogether, about 58% had continued their education. On the other hand, about 21% of those boys who entered college had subsequently dropped out. The reasons most often stated for drop out were failure (22%), financial difficulties (17%), and offer of a good job (10%).

By 1965, the proportions of young men going to college or some other post-secondary institution had increased appreciably, reaching 68%: the data for that year showed 40% had entered a four-year college, 12% a two-year college, 3% a technical institute, 1% a business college, 4% a trade or apprentice school, and 8% an armed forces school. Nineteen percent of this group dropped out, but for reasons subtlely different from those stated before: financial difficulties (18%), failure (11%), and fear of failure (7%).

Who Attended College?

For the purpose of studying the characteristics of high school graduates who attend college, two variables can profitably be examined, (1) a measure of general academic aptitude and achievement and (2) a measure of socioeconomic classification. If all students are grouped into quartiles on the two given variables, a matrix of 16 cells serves to classify the population. It is then possible to study the proportion in each cell which have attended various types of post-secondary institutions. Table 5 displays the results for males. Listed in the table for each socioeconomic and ability combination, is the proportion of males in that cell attending various types of institutions. Note, for example, that a large fraction of male students who are below average on the socioeconomic variable and above average on ability entered junior colleges.

It is revealing to study the distribution by socioeconomic and ability cell of students enrolled in technical schools. Table 6 is a display of such data, where the entries in the cells are percentages of the total male cohort belonging

TABLE 5.--Percentage of Males in Various Types of Post-High-School Institutions by Socioeconomic Status and General Academic Ability

Socioeconomic Quarter	Low				Low Average				High Average				High			
Academic Ability Quarter[a]	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Type of Institution:																
Four Year College	6	13	25	48	12	15	34	70	13	29	45	73	26	36	65	87
Junior College	4	6	6	13	5	7	11	7	8	9	10	8	12	16	11	5
Technical School	1	3	3	2	4	2	4	2	4	6	2	2	6	5	2	1
Trade School	3	2	2	1	2	8	2	1	4	3	2	0	3	2	3	-
Armed Forces School	3	16	9	9	9	10	11	5	4	8	11	5	13	5	5	1
None	78	60	55	27	68	58	38	15	67	45	30	12	40	36	14	6

[a]Ability Quarters: 1st=low; 2nd=low average; 3rd=high average; 4th=high

TABLE 6.--Distribution by Socioeconomic/Ability Cells of Males Enrolled in Technical Institutes

Socioeconomic Group	Academic Ability Quarter			
	Low	Low Average	High Average	High
Low	1	3	3	2
Low Average	4	2	4	2
High Average	4	6	2	2
High	6	5	2	1

to each cell. For example, 6% of all boys in the highest socioeconomic quartile and lowest academic ability quartile attended a technical institute. The most important observation which can be made from Table 6 is that students in technical colleges tend to have a socioeconomic status in the upper two quartiles of the population and academic abilities in the lower two quartiles. "Materially rich, scholastically poor" is the somewhat harsh generalization which has occasionally been made.

Characteristics of those Who Attended College

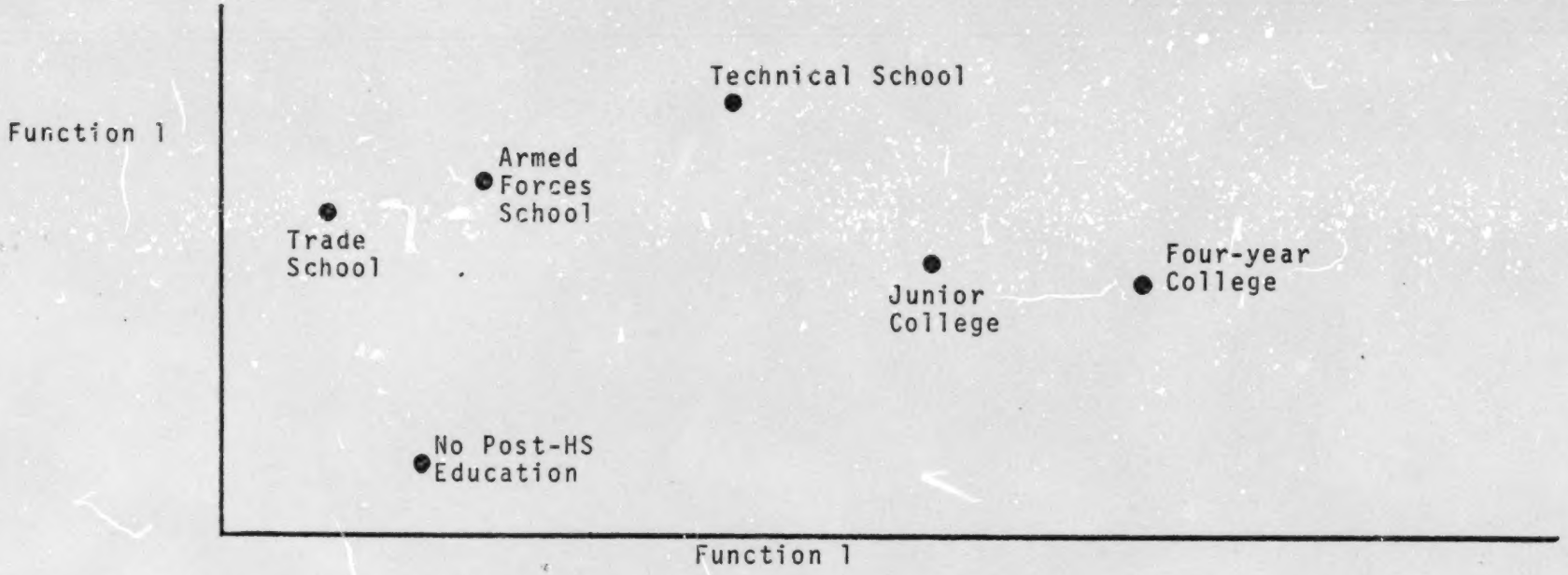
Although "general academic ability" and "socioeconomic status" are useful as variables to give a general picture of the six "college groups" into which high school graduates fall (i.e., four-year college, junior college, technical institute, trade school, Armed forces school, none), a combination of many variables can be used in a multiple group discriminant analysis to help clarify the differences between groups of students who select various educational alternatives. The discriminant analysis results in the plotting of a "centroid" for a group in a "discrimant space."

To form such a plot, scores on various psychological and information tests and certain socioeconomic factors are combined into two multicomponent functions which serve as cartesian coordinates for the discriminant space, with the components of each function weighted to produce the maximum discrimination between groups; then, the mean (centroid) for each group is plotted as a point. Figure 1 is a display of one such plot.

The description of the results of the discriminant space plot of Figure 1 in relative or comparative terms on an *ex post facto* basis for groups of students is straightforward; the value for predictive purposes for a single individual, however, may be somewhat less. Considering the function along the horizontal axis, for example, four-year college students and junior college students score high in mathematics information, have interest in physical science, understand word functions in sentences, and generally are the sons of mothers with relatively advanced education; these students show generally low mechanical-technical interest. Looking at the variables along the vertical axis, technical school students, for example, tend to have exceedingly high abilities to visualize in three dimensions and to read tables, have more mechanical interest and electrical information than any other group, but lack business information and general verbal ability; these students seem to come preponderantly from homes where they each had a room to himself (a chance to explore hobbies without interference from siblings?)

Of course, for any group identified, some members may have characteristics atypical of the group; the centroids plotted are group means only. In addition, individuals may enter or leave the group. However, follow-up studies made on the students whose test scores and other attributes were used in the analysis reported showed a substantial group stability. Individuals who left a group proved to have characteristics rather unlike the group they moved from and substantially like the group they moved into; their departure not only left their former group's centroid unaffected in location, but also left it with somewhat less internal variance.

FIGURE 1.-Centroids of Six "College Groups" of Males in a Discriminant Space of Intellective and Environmental Variables



Function 1

Mathematics Information →
Mother's Education →
Physical Science Interest →
Word Functions in Sentences →
Mechanical-Technical Interest ←

Function 2

Visualization in three Dimensions ↑
Table Reading ↑
Had own Room ↑
Mechanical-Technical Interest ↑
Electrical Information ↑
Business Information ↓
General English Information ↓

The Career Tree and the Stability of Career Choice

A Model of Career Development

Youngsters progress from elementary school and high school, possibly to college or other post-high-school education, and thence to careers. It is interesting to look at the stability of their educational and career plans as they mature, and it is helpful to have a model of career development to which reference can be made. One such model is the "career tree" discussed by Cooley and Lohnes in 1968.

The career tree is diagrammed in Figure 2. In this model, dichotemous choices are assumed at four levels of career development. A discussion of the diagram and more definitive descriptions of the "branches" appears in the text in the following paragraphs.

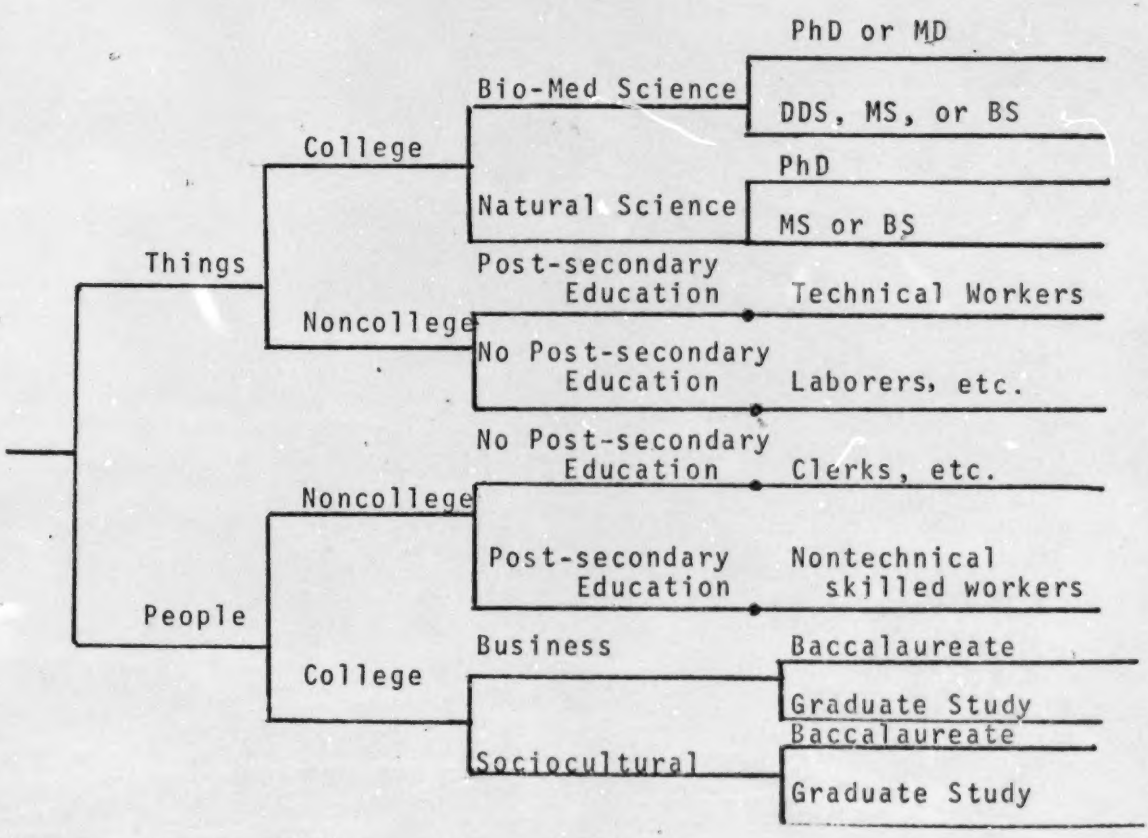


FIGURE 2.--Career Tree

The career tree assumes that abilities and interests tend to begin sorting out youngsters at about fifth or sixth grade into "things vs. people" orientations, that is, interest in various science, technology, mechanical or mathematical matters as opposed to interest in social, business, humanistic or cultural concerns. (*Project TALENT* found a remarkably stability--about 70%--in this orientation for at least five years.) At the beginning of their high school years, boys tend to have a "things" orientation; such boys outnumber those with a "people" orientation by about 2 to 1. By the time they are a year beyond high school, 48% of those who started with a technological orientation still retain it; 70% of those starting with a people orientation retain it.

A second level of career development occurs during high school when a boy makes preliminary plans for college. At this time the "tree" has four branches, as follows:

A. College Science or Technology
B. Noncollege Technology
C. Noncollege Nontechnology
D. College Nonscience

(In the list just given and hereafter in this section of the paper, "college" is to be interpreted as baccalaureate level or higher; "noncollege" may include associate degree education.) When these choices are made, they appear reasonably stable. A follow-up study of boys who had made such choices at the beginning of high school indicated that, four years later, 33%-50% remained on the path.

At "college freshman age", additional branches appear on the career tree, the result of dichotomizing each previous stem. This list of career plans is useful:

1. College, Biological-Medical Science
2. College, Physical Science or Engineering
3. Noncollege Technological, with Training
4. Noncollege Technological, no Training
5. Noncollege Nontechnical, no Training
6. Noncollege Nontechnical, with Training
7. College, Business
8. College, Sociocultural

These choices show more "path-jumping" than the previous ones, but still retain considerable stability. Table 7 contains appropriate data. The entries in the table show the percentages of boys following certain career plans; for example, the entry at cell 3-B implies that 20% of the boys who had plans when beginning high school to enter "noncollege technology" occupations later planned to be in a "noncollege technological, with training" career.

TABLE 7.--Stability of Career Choice of Boys: Plans at "College Freshman Age" as Compared to Plans When Beginning High School

Plans at "College Freshman Age" (See text for meanings of legends)	Plans When Beginning High School (See text for meanings of legends)			
	A	B	C	D
1	12	4	1	6
2	23	8	3	10
3	8	20	16	6
4	5	17	13	4
5	4	21	23	10
6	13	13	22	17
7	12	6	8	14
8	23	11	13	33

A final level of career development exists at Grade 16, the senior year of college or equivalent. Here, twelve variables will complete the career tree. These are listed below:

a. Ph.D.or M.D., Biological-Medical Sciences
b. D.D.S.,M.S., B.S., Biological-Medical Sciences
c. Ph.D., Physical Sciences and Mathematics
d. M.S. or B.S., Physical Science, Mathematics, Engineering
e. Skilled and technical occupations, with training
f. Laborers, No Post-High-School training
g. Clerks and Office Workers, No Post-High-School training
h. Noncollege, Nontechnical, with Post-High-School training
i. B.S. or B.A., Business
j. Graduate School, Business
k. B.S. or B.A., Sociocultural
l. Graduate School, Sociocultural

Table 8 shows the stability of plans between the college freshman and college senior age levels. The underlined entries represent stable career plans, i.e., percentages of males who still plan after several years the same career as originally. It is interesting that, in Table 8, cell e-3 (students who planned post-high-school technical training and actually persisted in this goal) and cell i-7 (students who planned college education in business and persisted in this goal) have the highest values of stability; it is further interesting to note that cells e-4, e-5 and e-6 of this table show relatively large entries, implying that young men who ultimately enter the technical occupations which require some post-high-school training had originally planned a technical career which did not require training (cell e-4) or a noncollege, nontechnical career which had (cell e-5) or did not have (cell e-6) a post-high-school training requirement.

TABLE 8.--Stability of Career Choice of Boys: Plans at "College Senior Age" as Compared with Plans When Beginning College

Plans at College Senior Age (See text for meaning of legends)	Plans at College Freshman Age (See text for meaning of legends)							
	1	2	3	4	5	6	7	8
a	20	1	0	0	0	0	0	1
b	19	3	4	1	2	1	1	4
c	2	6	0	0	0	0	0	3
d	8	40	14	3	2	7	11	.8
e	1	5	42	27	16	.18	3	7
f	0	0	4	27	18	1	0	0
g	7	4	9	18	31	6	6	3
h	2	7	17	16	21	34	11	5
i	8	12	5	1	40	14	45	14
j	1	3	0	2	0	2	4	2
k	17	11	5	5	5	15	15	32
l	15	7	1	0	1	2	4	21

Routes to Careers

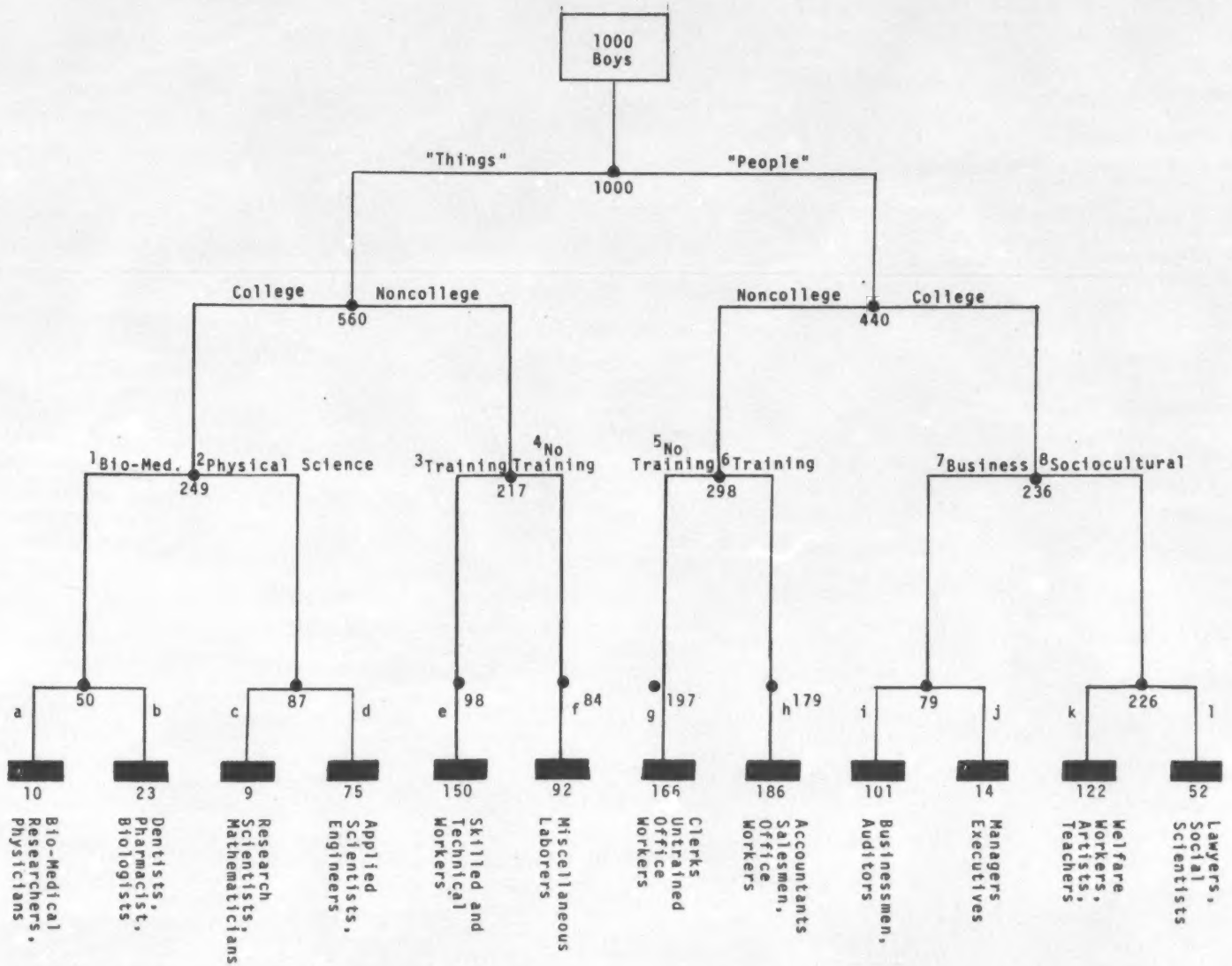
Data collected by *Project TALENT* reveal the statistical

relationships on career paths which are displayed in Figure 3. In this figure, legends are keyed to explanations given in the proceding paragraphs and are repeated only briefly on the figure itself. The data assumes an input population of 1000 boys. The numbers given at each branch represent data findings; that the numbers following a branch do not equal the number preceding the branch indicates that "path-jumping" (change of plan, entry into a stream from another route) has occured. It is especially interesting to note that approximately one-third of those who become skilled and technical workers had not originally planned such a career. It is also interesting to note that of the 249 boys who planned science careers early in high school only 117 persisted in these plans through the senior year of college. The data also tend to indicate that more boys leave the "things-oriented" stream altogether than remain in it at a level lower than their original aspirations.

Comparison of Technicians With Other Scientific-Technical Workers

Research scientists, engineers, technicians, and other technical workers can be discriminated from each other and from certain other occupational groups by using multiple regression factor analytic techniques. This analysis method employs scores on a multiple battery of psychological tests and interest inventories as predictor variables and takes occupational categories as criterion variables; one result of such a treatment is the identification of those traits, aptitudes and interests which are most useful in predicting a future occupation and, hence, most likely to be associated with individuals in that occupation. (See Figure 3 and accompanying discussion.) In what ways and to what extent, then, do these special groups of scientific-technical workers differ?

FIGURE 3.-Routes to Careers, Age of High School Beginning to One Year Beyond Baccalaureate



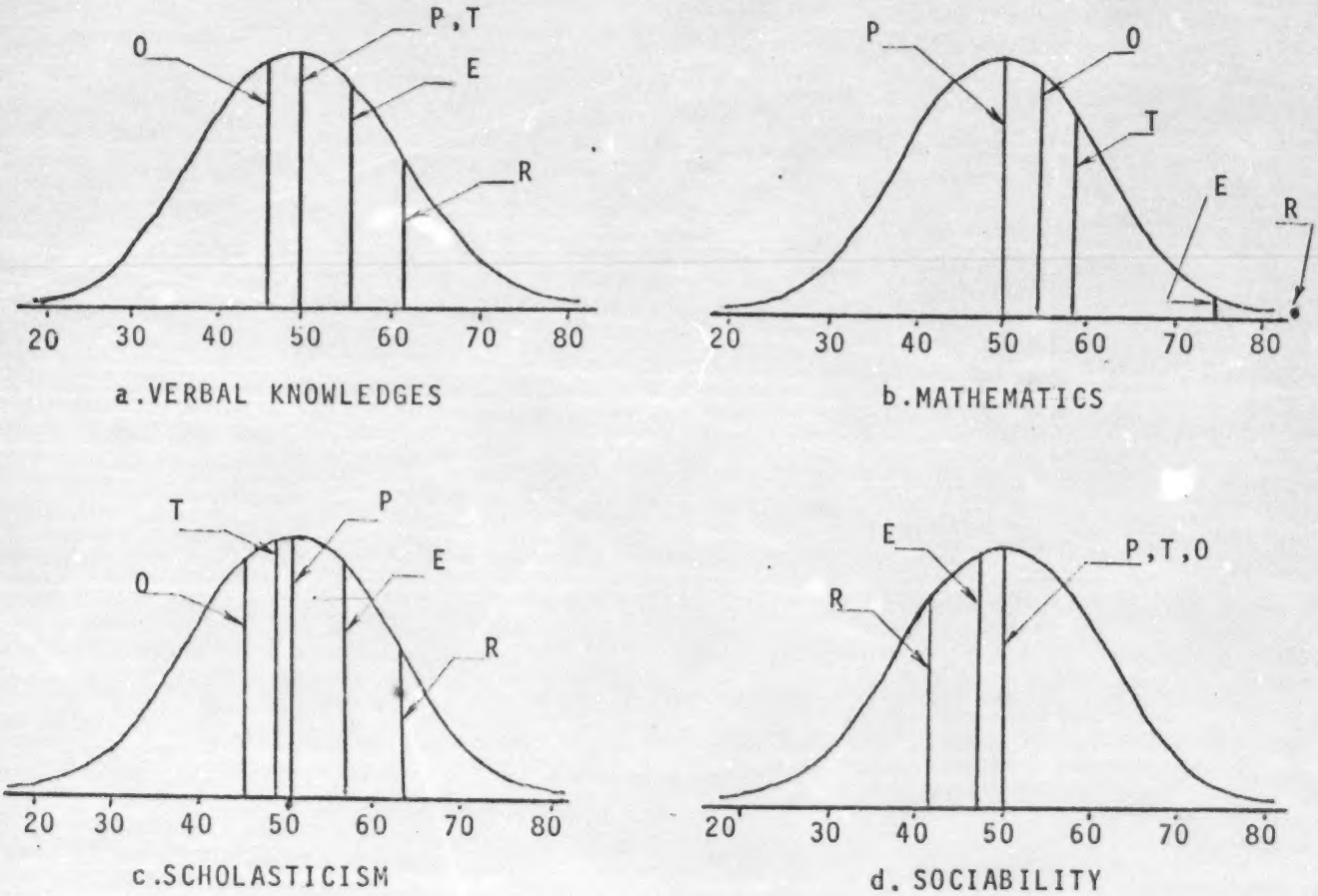
Project TALENT attempted to answer this question. In a study of individuals who were five years beyond high school--in theory, one year past a baccalaureate level--some interesting differences in the group means for certain discriminating factors were revealed. Table 9 lists these. In the table, the "factors" are combinations of test scores and interest inventories which were collected when the individuals were high school seniors, the "group" consist of individuals employed in or in the last stages of preparation for the occupations listed, and the numbers given in the body of the table are group means on scales with a defined population mean of 50 and standard deviation of 10. Figure 4 repeats certain of these data in graphical form.

TABLE 9.--Comparison of Group Means for Research Scientists, Engineers, Technicians, and other Technical Workers on Certain Discriminating Psychological Test Factors

Factor	Group[a]			
	Research Scientists	Engineers	Technicians	Other Technical Workers
Verbal Knowledges	61	56	50	46
Mathematics	84	74	59	54
Visual Reasoning	60	61	60	57
Business Interests	45	47	46	47
Scholasticism	63	57	49	46
Outdoor or Shop Interests	60	64	67	69
Cultural Interests	38	35	35	34
Science Interests	72	69	61	56
Sociability	42	48	50	50

[a]These "groups" are also to be identified respectively with branches c,d,e, and f of the Career Tree, Figure 3.

FIGURE 4.--Distribution of Selected Characteristics among High School Graduates, with Location of Group Means for Certain Classes of Technical Workers.



Legend:
P= population mean (defined as 50, S.D.=10)
R= research scientists
E= engineers
T= technicians
O= other technical workers

The factor which most discriminates these four groups is, predictably, mathematics aptitude and achievement. (See Figure 4b). Research scientists have for this factor a group mean which is 3.4 standard deviations above that for the population as a whole! Statistically, such a mean places this group above the 99.9 percentile level. Engineers, as a group, score 2.4 standard deviations higher than the population mean (98th percentile), and technicians nearly one standard deviation higher than the population mean (82nd percentile). Other technical workers, those who have received no post-high-school training, score only slightly above the population mean in mathematics ability.

"Verbal knowledges" also serve to discrimate. Research scientists score somewhat higher on this factor than engineers, both at about one standard deviation above the population mean. Technicians score at the population mean, unschooled technical workers below it. "Scholasticism", a factor representing interest in following academic pursuits, also is a discriminant. Engineers and research scientists are well above the mean in a distribution of this trait, technicians and other technical workers below. Finally, "sociability"--an indicator of interest in people, organizations, and group activities--is another interesting discriminant. Both research scientists and engineers score below the population mean on this trait, the latter to a lesser extent; technicians and other technical workers score at the mean. The inference is that scientists and engineers tend to be introverted, inner-directed, and disinterested in sociocultural or political activities.

All technological workers appear to have certain traits in common that distinguish them from the population as a whole. For example, they all score high on tests of visual reasoning, they are somewhat less interested than the "average person" in business matters, they display marked interests in outdoor or shop-related activities, and they have a significant lack of cultural interests. Predictably, the "science interest" scores of this group exceed the population mean by at least one standard deviation.

Summary: Characteristics of Engineering Technology Students

What is his Background?

The engineering technology student, as the graduate of an American High School, is most likely to have come from a "small" secondary school in a rural or small town environment. If he is from the northeast, his preparation for advanced study is likely to be good; if he comes from the southeast, he is apt to lack some important preparation; if he comes from the western or midwestern regions of the nation, his preparation will be adequate but not outstanding; if he has graduated from a vocational high school, he is apt to be poorly prepared; and if he is from a large urban center, the quality of his school with be closely related to the quality of housing in the neighborhood. He is very likely to have followed an "academic" curriculum, but he is not likely to have had the opportunity to study physics or advanced math.

He is not likely to have participated in "enrichment programs" or extra-curricular activities while in high school, even though these were available. His achievement in English is average, his achievement in mathematics is high average, but his overall scholastic record probably places him in the lower half of his class.

The engineering technology student is likely to come from a family with above average means; the boy, himself, probably did not share a room at home.

What Personality Traits Does He Have?

The engineering technology student is likely to have been "things oriented" from an early age. He probably has been fairly stable in his selection of careers and of career development routes; for example, it is slightly more likely that he has upgraded his plans from a career requiring no training than that he originally aspired for a sophisticated career and subsequently

adjusted downward his goals. He has little sociocultural interest, but does have an "outdoors or shop" orientation. He is unusual in having a high degree of ability to visualize in two or three dimensions. While having mathematical aptitudes above the population mean, these traits are considerably less pronounced than in engineers or research scientists.

He is a member of a surprisingly small proportion of the population; considering the various aptitudes and attitudes which research has shown to be common to most such individuals, it is unlikely that more than 2% of the total population of high school graduates fall into this category.

How Valid is this Profile?

Every individual is in some ways unique, so that it is unlikely that the generalizations given in the preceding paragraphs of this section all apply to any single individual. What have been reported are "means," "norms," and "central tendencies" for groups of individuals, not characteristics of any one person. Readers are urged to exercise the utmost caution in applying these generalizations.

Implications for Engineering Technology Education

Because there exist in common for high schools of various types certain basic characteristics, because the aspirations of young people historically fall into certain patterns, and because it has been possible to identify the attributes of individuals who have successfully climbed a career tree to an engineering technology occupation, the following observations may have relevance to educators in the domain of engineering technology:

(1) Highly selective admissions policies in educational institutions will eliminate many of the individuals who aspire to careers in engineering technology.

(2) Admissions prerequisites, other than algebra and possibly trigonometry, are unrealistic for most of the country. Physics, for example, often does not appear in high school curricula.

(3) Except in unusual cases, students will not have encountered drawing, shop work, etc., in high school.

(4) Students are not apt to be "academically inclined" (they are much less so than science majors or engineering majors) and should probably not be subjected to an initial "hard core theory" schedule.

(5) Students are apt to be disinterested in English and sociocultural matters; great skill must be employed to introduce such vitally needed subjects into the curriculum.

(6) Since only a small proportion of the population seems identifiable as "engineering technology material", colleges with small service areas will probably continue to have difficulty attracting enrollment; regional centers seem indicated for all but urban communities with a high population density.

(7) Because research scientists, engineers, and technicians have similar attributes in all but a few areas, the counseling task will require herculean efforts. And since other factors seem to have more influence on career choice than counseling, it seems unlikely that formal counseling will produce in the near future any significant results.

(8) Aspirations for careers show a great deal of stability. There has been, however, more lateral movement to different kinds of careers than vertical movement to lower levels of a career field. Vertical adjustment to higher levels does occur with some frequency. Routes to satisfy upward aspirations need to exist, otherwise losses from the field occur. Technical institutes should,then, provide attractive entry methods for those young people who did not originally plan post-high-school training but later revise their plans upward. Similarly, provisions should exist for transfer from business or other career tree branches to the technical branch.

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